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**IL BOSCO: BENE INDISPENSABILE
PER UN PRESENTE VIVIBILE E UN
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ABSTRACT BOOK



Detection and characterization forest harvesting in piedmont trough Sentinel-2 imagery : a methodological proposal

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This work has been developed to verify if and how Sentinel-2 A / B (S2) multispectral satellite images can enter, like institutional use, the ordinary workflow of the piedmont regional forest administration. The priority is detect, at the regional scale, changes in forest cover at least every year with two objective: identification of potential forest cuts area not according to Forestry Regulation and quantifying their intensity to direct forest police controls. For the following case study two S2 images were used, calibrated at ground reflectance values, acquired at the maximum vegetative activity of the forest surfaces, correspond to the months of August for the seasons 2016 -17. The study area cover a portion of Val Tanaro (CN) of about 95 km². To isolate the wooded areas, the Piedmont Forestry Map was used as a mask. In order to isolate the only highly vigorous vegetative component at the moment observed, a 2016 NDVI map was generated using a threshold equal to 0.6. In this preliminary phase, three cutting areas authorized were recognized and bordered by interpreting the high resolution real-color satellite orthophotos available in Google Earth (updated to 2018). The resulting polygons were used as reference for subsequent processing. At each, by means of zonal statistics, average spectral signatures were derived from both the multispectral image preceding the cut (2016) and the subsequent (2017), exploring the region of the spectrum between 443 and 2190 nm. These were compared for difference (after cutting - before cutting) band by band, obtaining a reference curve with a characteristic trend resulting by cover change with moderately positive values in the visible region (VIS), negative in the near infrared (NIR), and strongly positive in the shortwave infrared (SWIR). Then a matrix difference was made, $D(x, y, i)$, band by band, between two images (August 2017 - August 2016). The assumption is to operate not by pixel but by area, $D(x, y, i)$ has been previously segmented by *Orfeo ToolBox software v. 6.4.0* using a local operator with a 5 pixels S2 radius. For each segmented polygon we calculated corresponding zonal statistics like mean (μ_{Di}) and standard deviation (σ_{Di}) for each band (i) of the pixels contained in the polygons and belong to $D(x, y, i)$. The polygons were subsequently subjected to 10-cluster automatic *k-means* classification, using only μ_{Di} as the cluster discriminant. To assesses clusters



interpretation mean signature of differences was compared with the reference one previously defined excluding those clusters in which, in the spectral macro regions, the required condition $VIS > 0$ AND $NIR < 0$ AND $SWIR > 0$ did not occur for the cutting condition polygon. For the remaining clusters, the Pearson correlation coefficient (R) was calculated between the average polygon signature and the reference one. The value of R, stored as a new attribute of the previously filtered polygons, makes it possible to establish a priority of the controls, meaning that the areas with the highest R values ($R > 0.9$) are the most likely areas to be affected by cut. In order to derive information about the intensity of the cuts, for each polygon new zonal statistics ,average (μ_{ndvi17}) and standard deviation (σ_{ndvi17}), were calculated from 2017 NDVI map. The standard deviation was assumed as proxy of intensity of the with this interpretative key: low values of σ_{ndvi17} correspond to conditions of greater homogeneity surface, suggesting a clearcut. High values of σ_{ndvi17} correspond to conditions of greater heterogeneity surface suggesting a minor cut like partial harvesting. On the base of the main and secondary species and the type of cut performed, the cutting authorizations have been categorized into 7 functional types:

- (i) cutting in pure broadleaf stands;
- (ii) maturity cutting in pure broadleaf stands;
- (iii) partial harvesting in pure broadleaf stands ;
- (iv) maturity cutting in pure conifer ;
- (v) Partial harvesting in pure conifer ;
- (vi) maturity cutting in mixed woods ;
- (vii) partial harvesting in mixed woods.

Future developments are desirable to validate in what functional type this workflow shows the best results. The proposed methodology will allow to standardize the forest harvesting monitoring to improve its effectiveness, moving from a control by sample areas (currently about 5% of the requests) to entire regional control on the wooded area concentrating priority on the areas thus detected by previous mentioned method.



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